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PROJECT DESCRIPTION

NIGLINTGAK GAS DEVELOPMENT PROJECT

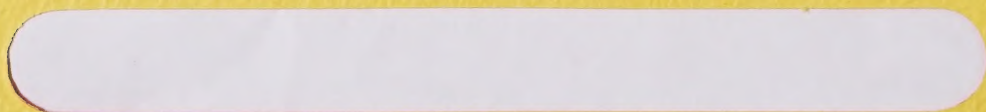
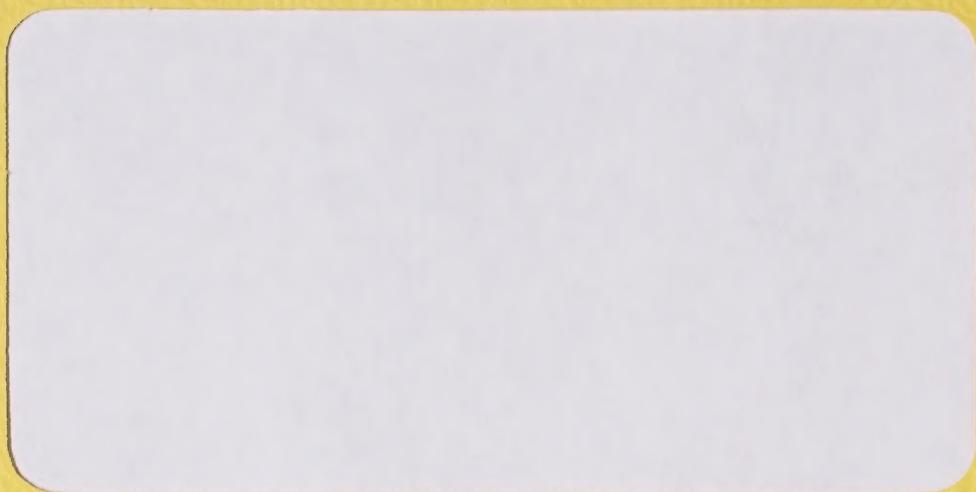
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PROJECT DESCRIPTION

NIGLINTGAK GAS DEVELOPMENT PROJECT

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PREPARED EVIDENCE FOR THE MACKENZIE VALLEY PIPELINE INQUIRY

INUVIK, N.W.T.

JANUARY, 1976

SHELL CANADA LIMITED
CALGARY, ALBERTA



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PROJECT DESCRIPTION OF THE
SHELL NIGALINGAK GAS DEVELOPMENT PROJECT

Evidence of a panel consisting of

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J. M. Serra

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PROJECT DESCRIPTION OF THE
SHELL NIGLINTGAK GAS DEVELOPMENT PROJECT

Evidence of a panel consisting of

R. E. Faulkner

J. W. Serra

I. INTRODUCTION

The Niglintgak gas development project planned by Shell Canada Limited will process a maximum of 150 million standard cubic feet per day of raw non-associated natural gas reserves from the Niglintgak field in the Mackenzie River Delta region of the Northwest Territories. The gas reserves in the Niglintgak structure have been only partially delineated and therefore the information presented herein represents our best judgement at this time as to the manner of development of the accumulation. Shell Canada Limited anticipates that further delineation drilling and engineering studies will result in changes to the development plan described herein but the general scope of the project should not alter significantly.

Until recently Shell anticipated that gas produced from the Niglintgak accumulation would be transported to and processed at a gas plant at Taglu (some 10 miles east of Niglintgak), owned and operated by Imperial Oil Limited. Shell has now evaluated a number of alternative processing schemes and has concluded that the Niglintgak accumulation can best be developed by processing the gas in a plant constructed and operated by Shell at Niglintgak.

The major surface facilities making up the proposed Niglintgak gas development project are shown in Figure 1. The gas processing plant and major support facilities such as living accommodations, helicopter pad and warehouse will be located near the projected geographic centre of the Niglintgak gas reserves. Well locations have been selected to provide adequate drainage points for the multiple non-associated gas bearing

sands and fault blocks making up the Niglintgak accumulation. Well depths and designs vary from location to location depending on the depth and number of producing zones to be encountered. The unloading dock and staging area will be located on the Kumak channel, east of the plant site, to take advantage of the deep water that occurs naturally along that stretch of the river.

Two major gathering lines, one serving the north end of the field and the other the south end of the field will transport well production to the central gas processing facility. The gathering lines will be supported above ground on pile supports except for the line segment servicing the most southerly well where the Kumak channel crossing may require burial of the line if it cannot be suspended. However, we are still studying the technical and economic feasibility of tying in this well. Gathering line segments will vary in size from approximately 8 inches to 16 inches in diameter and will be designed to withstand a maximum operating pressure of approximately 1400 psig and a maximum gas temperature of 100°F. The gathering lines will transport raw gas to the central gas plant where all processing will take place.

The central processing plant pad, well pads, the road and the dock and staging area will be constructed of native granular construction materials. The closest proven source of gravel is the Ya-Ya lake deposit located approximately 30 miles south east of the plant site. The Ya-Ya lake deposit and the anticipated gravel haul route is shown on Figure 2.

Figure 1 also indicates a possible route for a sales gas transmission line lateral to be constructed by others. The actual location of the line will be determined by the transmission line operator at a later date and the connection to the transmission line will be located at the gas plant gate. The gas plant design includes gas refrigeration facilities in anticipation that the transmission line will be buried below ground and will transport chilled gas.

17. RESERVES

The existing Farewell staging area currently operated by Shell as a base for exploration operations in the delta area is located approximately 10 miles south of the proposed Niglintgak gas plant. Shell Canada Limited intends to use Farewell as an operations center during the development drilling and certain construction phases of the project and as a transfer point for personnel and air cargo once the gas plant is operational. Personnel and cargo travelling to the Niglintgak plant will be flown to the Farewell staging area by fixed wing aircraft and then on to the plant by helicopter. An all weather airstrip suitable for STOL aircraft has already been constructed at the Farewell site. Shell assumes that the Farewell staging area will be operated by Shell and/or other operators during the life of the Niglintgak project as a base for exploration and drilling operations in the region.

Shell Canada Limited estimates that the recoverable non-associated ultra gas reserves in the Niglintgak accumulation total 402 million standard cubic feet (mcf). This total is comprised of 412 MCF proven reserves, 302 MCF probable reserves and 284 MCF possible reserves. These totals have been derived on the basis of data obtained from the wells drilled on the structure prior to the Niglintgak 8-19 well that is currently being drilled. Shell Canada Limited anticipates that the 8-19 well will transfer significant additional reserves from the probable and possible categories into the proven category and any results in an increase in the total estimated reserves in the accumulation.

Table 3 provides a representative composition of the gas stream to be processed in the Niglintgak gas plant over the life of the field. The composition is based on a mixture of production from the shallow and deeper gas zones in the Niglintgak structure. The shallow gas zones contain in excess of 90% methane and only trace amounts of the heavier hydrocarbons. Gas from the deeper zone is enriched rather in the heavier hydrocarbons. The blend of the two gas streams will provide an inlet stream to the plant that contains approximately 2 barrels of recoverable liquid hydrocarbons (pentane) plus per million cubic feet of gas. The liquid hydrocarbons recovered during processing will normally be burned as plant fuel.

II. RESERVES

The Niglintgak structure is a long narrow anticline with the major axis running approximately north west and south east. The structure is transected by several faults that create discontinuities in the gas bearing sands and may create separate non-communicating fault blocks within the structure. The structure also contains a number of different sands varying in depth from approximately 2600 feet to 7000 feet below ground elevation that contain non-associated gas reserves. Gas reserves contained in the various sands are at different temperatures and pressures and also show minor variations in composition. The major portion of the reserves are contained in the shallowest sands at relatively low pressures.

Shell Canada Limited estimates that the recoverable non-associated sales gas reserves in the Niglintgak accumulation total 887 billion standard cubic feet (BCF). This total is comprised of 402 BCF proven reserves, 301 BCF probable reserves and 184 BCF possible reserves. These totals have been derived on the basis of data obtained from the wells drilled on the structure prior to the Niglintgak B-19 test that is currently being drilled. Shell Canada Limited anticipates that the B-19 well will transfer significant additional reserves from the probable and possible categories into the proven category and may result in an increase in the total estimated reserves in the accumulation.

Table 1 provides a representative composition of the gas stream to be processed in the Niglintgak gas plant over the life of the field. The composition is based on a mixture of production from the shallow and deeper gas zones in the Niglintgak structure. The shallow gas zones contain in excess of 98% methane and only trace amounts of the heavier hydrocarbons. Gas from the deeper sands is somewhat richer in the heavier hydrocarbons. The blend of the two gas streams will provide an inlet stream to the plant that contains approximately 2 barrels of recoverable liquid hydrocarbons (pentanes plus) per million cubic feet of gas. The liquid hydrocarbons recovered during processing will normally be burned as plant fuel.

Preliminary reservoir engineering studies indicate that the Niglintgak gas reserves can be adequately drained with the 10 wells shown on Figure 1. Several of these wells will be completed with dual tubing strings to allow concurrent production of both deep and shallow gas reserves within the same wellbore. The remaining wells will be single zone completions in the shallow sands only. The widely separated locations of the 10 development wells eliminates the possibility of using cluster drilling concepts for all wells with the possible exception of the four locations in close proximity to the gas plant. Further design is required to determine if the four centrally located wells can be directionally drilled from a single surface location. For the present Shell has assumed that ten separate drilling pads will be required, one for each well.

The most southerly well in the proposed development is physically separated from the remainder of the Niglintgak project by the Kumak Channel. There are several factors that must be better defined before the tie-in of this well to the remainder of the system can be considered physically and/or economically viable. Very little is known at this point in time of the physical characteristics of the Kumak channel in the vicinity of the proposed pipeline crossing site or of the feasibility or cost of constructing either a buried or suspended pipeline crossing in this stretch of the river. Limited hydrological survey data in the area suggest that a crossing of any sort would be extremely expensive to construct and moreover would have a high potential of accelerating river-bank erosion along the north shore of the channel if the design was not adequate. Shell has elected to include this well site in the present development plan as it is the only feasible surface location from which the shallow gas reserves underlying the region (estimated to be 6 - 8% of the total Niglintgak accumulation) can be drained. Shell intends to carry out additional work regarding the feasibility of drilling and tie-in in this particular well and understands that a rigorous examination of the proposed river crossing design would be carried out by DIAND before a construction permit would be issued. In any event, Shell believes that the gas reserves that can be drained from wells located north of the Kumak Channel will be sufficient to support the proposed Niglintgak plant if the river crossing does not prove to be physically or economically viable.

III. LAND REQUIREMENTS

Figure 1 defines the approximate surface locations on which Shell will construct the permanent facilities comprising the Niglintgak gas development project. These land requirements include:

- (a) The surface leases required for the ten gas well locations, the gas plant and associated support facilities, the dock and staging area and the access roads.
- (b) An additional surface lease located adjacent to the gas plant that will be required for the installation of supplementary gas compression facilities during the later years of the project.
- (c) The easements required for the gas gathering lines including both the above ground portions of the gathering system and the proposed buried crossing of the Kumak Channel.

As noted in the Introduction, Shell also intends to make use of the existing Farewell staging area and airstrip in constructing and operating the Niglintgak development. The staging area and airstrip are currently held by Shell under a renewable five year lease arrangement from the Federal Government, Department of Indian Affairs and Northern Development. Shell anticipates that the facilities located at Farewell will be operated by Shell and or others for many years to come and that said facilities, particularly the airstrip, will be available to Shell throughout the life of the Niglintgak project.

The Ya-Ya lake gravel deposits located approximately 25 miles south east of the proposed gas plant site will be the principal source of the granular materials required for the Niglintgak project. Shell anticipates that approximately 800 thousand cubic yards of gravel will be required from the Ya-Ya deposits during construction of the project and that a further 50 thousand cubic yards per year will be required throughout the life of the project for maintenance purposes.

IV. WELL DRILLING AND COMPLETION

Drilling of the majority of the producing wells (anticipate total of 10) required to drain the Niglintgak accumulation will probably be drilled commencing in 1978 or 1979 and be carried out as a continuous one rig program until drilling and completion activities are completed. Shell hopes to re-enter and complete both the M-19 well (suspended in 1975) and the currently drilling B-19 well as production wells in the shallow sand package. If re-entry and completion operations are successful the number of additional wells will be accordingly reduced.

Wells will be drilled by a Drilling Contractor under the supervision of Shell. Drilling supplies and fuel will be stockpiled at the Farewell staging area and transferred to each drilling site as required over ice roads in the winter months or via helicopter during the remainder of the year. Resupply of the Farewell staging area will be conducted each summer by river barge from Hay River.

Production well depths will vary from approximately 4000 feet true vertical depth (TVD) for a shallow sand producer only to approximately 7000 feet TVD for a well that is also completed in the deeper sands. Elapsed times including rigging up, drilling and dismantling equipment in preparation for movement to the next location will probably vary from 90 to 120 days per well depending on well depth. All wells are located within the Kendall Island Bird Sanctuary and the timing of rig moves will be governed by restrictions laid down by government regulatory authorities. Following drilling operations, wells will be suspended without production tubulars to guard against possible well damage from potential freezeback problems.

At this time Shell anticipates that development drilling at Niglintgak will be carried out using a helicopter transportable drilling rig similar in design to the exploration rigs that have been under contract to Shell in the area for several years. The helicopter transportable rig can be moved from location to location during periods of the year when winter roads cannot be constructed and should minimize rig standby time, particularly in a field like Niglintgak where well locations are widely spaced and are not linked by permanent roads.

The rig will be entirely self contained, complete with electrical power generation facilities, fuel storage, utility systems and living accommodations for about 50 men. The major pieces of drilling equipment, drawworks, rotary table, mud pumps, etc. will probably be electrically powered D.C. units fed from primary diesel - electric generator sets.

Blow out prevention equipment and casing programs employed in drilling production wells will meet Company and Federal Government standards.

The rig substructure will be supported on a prepared timber pile foundation to ensure that adequate support is provided under this critical area of the rig. Pile supports may also be installed under other heavily loaded portions of the rig but the majority of the rig facilities can probably be set directly on the gravel pad surface.

As with current exploration wells several operations, namely the construction of pile foundations, a drilling sump and the installation of the initial string of casing or conductor pipe, will be completed by construction crews prior to the arrival of the drilling rig. Present practice consists of setting 26 inch diameter conductor pipe to a depth of 60 feet below ground surface. The upper 30 feet of the conductor pipe are fitted with refrigeration coils to ensure that the surface layer of permafrost remains competent during drilling operations.

V. WELL FACILITIES AND GAS GATHERING SYSTEM

Drilling operations below the conductor pipe will be carried out by the drilling rig. Well designs and casing setting depths will vary from site to site depending primarily on whether or not the well will be completed as a dual or single zone producer. Figure 4 depicts a typical well design envisaged by Shell for a shallow single zone producing well. A dual zone producing well will incorporate similar design features but casing and tubing sizes and setting depths will vary accordingly.

The producing well design contained in Figure 4 differs from current exploration wells in one significant aspect, the elimination of the so-called permafrost casing string that regulations require to be set at 500 feet. The 26 inch surface casing string will be set at approximately 1100' and the 13-3/8 inch casing will be set at approximately 2400 feet above the overpressured shallow gas zones that have been encountered routinely in drilling at Niglintgak.

A firewater heater will be required at each well to raise the produced gas temperature sufficiently to prevent hydrate formation in the gathering line. The firewater heater will be an indirect fired type and will burn raw wellhead gas as fuel. A boiler will make part of the firewater heater to provide a water source for the controls and valves. The heater will also contain the above mentioned safety water.

Hydrogen sulfide and corrosion inhibitor injection pumps will be provided at each well location and would be housed in a well head building. These pumps will be capable of injecting chemicals into both the production well and the gathering line to prevent hydrate formation and corrosion. The hydrogen sulfide and corrosion inhibitor will be stored in small metal tanks located on the pad and will be surrounded by a dyke with sufficient capacity to contain spills.

V. WELL FACILITIES AND GAS GATHERING SYSTEM

A gravel pad will be constructed at each well location which will be large enough to contain the required well facilities and also serve as a work area for a workover rig if it is required in the future. Present plans call for a gravel pad of about 200' by 300' dimensions and sufficiently thick to prevent permafrost degradation. A dyke will be constructed around the pad to protect the area from seasonal floods and to contain minor spillages.

The wellhead will be located within the pad area and would consist of the master valves and also a surface safety valve. The surface safety valve will be able to operate manually or automatically and will also be able to be activated remotely from the gas plant. An orifice meter will be located downstream of the surface safety valve to measure production from each well. This meter will also be capable of being monitored from the gas plant along with pressures, temperatures and other functions at each well location.

A lineheater will be required at each well to raise the produced gas temperature sufficiently to prevent hydrate formation in the gathering line. The lineheater will be an indirect fired type and will burn raw wellhead gas as fuel. A building will house part of the lineheater to provide a warm area for the controls and valves required and will also contain the above mentioned orifice meter.

Methanol and corrosion inhibitor injection pumps will be provided at each well location and would be housed in a small heated building. These pumps will be capable of injecting chemicals into both the production well and the gathering line to prevent hydrate formation and corrosion. The methanol and corrosion inhibitor will be stored in small metal tanks located on the pad and will be surrounded by a dyke with sufficient capacity to contain spills.

A flare knockout drum, recycle pump and flare stack will be provided to permit blowdown of facilities located on the pad for maintenance or repair. The flare knockout drum will likely be housed in the line heater building and the recycle pump will be located in the methanol pump building. Liquids separated in the flare knockout drum will be stored in a steel tank located within the dyke with the methanol and corrosion inhibitor tanks. Liquids will be pumped back into the gathering line from the storage tank with the recycle pump.

Pig injector facilities will be installed at the well locations to permit pigging of the gathering line if required. These facilities will also allow a linalog device to be run through the gathering system to check for corrosion.

A field gathering system will be required to transport gas from the production wells to the processing plant. Gathering system routes are depicted in Figure 1. The gathering system will consist of common gathering lines transporting gas from a number of wells. A detailed hydraulic analysis has not been carried out yet but preliminary calculations indicate line sizes will vary from 8" to 16" diameter.

The lines will be founded on pile supports at an elevation above the ground that is sufficient to ensure the lines would be above maximum anticipated flood levels and storm surges. The lines will be horizontal or sloped slightly, if possible, towards the gas plant to prevent liquid hold-up.

All lines will be insulated and heat traced. The insulation will be thick enough to maintain the gas temperature above the hydrate point under normal flowing conditions. Under upset conditions such as low flow or start-up or shut-down, the heat trace system will be activated to maintain the gas temperature above the hydrate point. The heat trace system will be equipped with temperature sensing devices so that it will be automatically activated when the temperature drops to a predetermined level.

VI. PROCESSING FACILITIES

The Shell Niglintgak Gas Plant will be built near the geographic centre of the Niglintgak accumulation. The Plant will be designed to process 150 million cubic feet per day of raw gas to meet pipeline gas quality specifications. A representative analysis of the gas stream to be processed is provided in Table 1. The gas stream does not contain any hydrogen sulphide, or sulphur in any form. Table 2 provides a material balance for the Niglintgak gas plant.

All plant facilities will be enclosed in heated and insulated buildings connected by a system of utilidors which will carry utilities and provide protected passage between buildings for personnel and vehicle traffic. Plant buildings will be founded on piles above prepared gravel pad to prevent thermal degradation of the permafrost and to provide elevation above flood levels.

At the Niglintgak Plant, the raw gas will undergo initial gas-liquid separation after which it will be dehydrated and then refrigerated to remove liquefiable hydrocarbons. The residue gas will then be compressed, cooled, and delivered to the sales gas transmission system. Recovered liquids will be used as fuel. Aerial coolers will be used throughout the process in lieu of providing a cooling water system. A glycol/water heat medium system will be used for process and building heating. Gas turbines will likely be used at prime movers for gas and propane compression and power generation.

VIII. CONSTRUCTION

VII. SUPPORT FACILITIES(a) Well Pads and Facilities

Support facilities will be provided to make the gas plant completely self-sufficient. The plant will have a warehouse with an inventory of spare parts and supplies and a maintenance shop for routine equipment repair. Accommodation and recreation facilities will be provided at the plant site for the operating staff. Helicopter pads will be provided at the plant and at remote well locations and a river dock will be provided on the Kumak Channel for the unloading of supply barges. The utility systems will include raw water treatment and sewage treatment facilities, gas turbine driven power generators, process and building heating systems and a voice and data communications system between the plant and well sites, and the plant and Calgary.

Permanent facilities to be located at each well site will be erected as a part of the gathering system construction activities noted in (c) below.

(b) Gas Plant

Work carried out by the prime contractor and his subcontractors will include preparing the site, moving and placing gravel or sand, installing piles for foundations, constructing a dock, erecting large field-fabricated storage tanks, and, if necessary, some dredging. Work done elsewhere will include the fabrication of large and small prefabricated modules which will be installed on site to form the plant. Work at the Hightank site will include interfacing, testing, and commissioning the prefabricated modules, and erecting buildings including workshop, warehouse, garage, utilities, control room, and both permanent and temporary housing.

VIII. CONSTRUCTION

(a) Well Pads and Facilities

Gravel-pad construction at the well sites will involve moving and placing large amounts of gravel. Open sumps suitable for containment of drilling fluids and sewage will be constructed in preparation for the arrival of drilling rigs. The work will be carried out chiefly in winter. It is anticipated that gravel will be transported to the site over snow or ice roads directly from the pits. Heavy construction equipment will be used, and crews will be housed at a central base camp and transported daily to and from the construction site.

Permanent facilities to be located at each well site will be erected as a part of the gathering system construction activities noted in (c) below.

(b) Gas Plant

Work carried out by the prime contractor and his subcontractors will include preparing the site, moving and placing gravel or sand, installing piles for foundations, constructing a dock, erecting large field-fabricated storage tanks, and, if necessary, some dredging. Work done elsewhere will include the fabrication of large and small completed modules which will be installed on site to form the plant. Work at the Niglintgak site will include interfacing, testing, and commissioning the prefabricated modules, and erecting buildings including workshop, warehouse, garage, utilities, control room, and both permanent and temporary housing.

Scheduling will be designed to level work loads, allow projects to be carried out in the most suitable season, ensure efficient logistics support, and provide maximum protection for the environment.

Figure 3 presents current best estimates of the construction schedule required to meet a plant start-up date of 1981.

(c) Gas Gathering System

Construction of the pipeline systems linking producing wells to the gas processing plant will be carried out in winter, except for certain activities at well or plant sites where work will be confined to gravel pads. Crews will be accommodated at central base camps and transported daily to and from the construction site. Activities along the right-of-way will consist primarily of the following phases:

- i) Preparing the right-of-way clearing brush and preparing snow roads to carry construction vehicles.
- ii) Constructing pile supports, and positioning, welding, and insulating the pipe.
- iii) Pressure-testing completed installation.

Heavy equipment will be required in all phases. Pile foundations will be sunk at least a month before pipe-laying, to be sure the piles were properly frozen in before being loaded. Pipe assembly facilities will be set up at the central base camp, and as much prefabrication as possible will be carried out before transporting pipe sections to the installation site.

(d) Construction Schedule

The nature of the project, will require that certain activities must be accomplished during specific times of year.

Specifically, all major shipments of material will have to be made in summer, while many other activities, such as gravel hauling, may be better carried out while the ground is frozen.

Scheduling will be designed to level work loads, allow projects to be carried out in the most suitable season, ensure efficient logistics support, and provide maximum protection for the environment.

Figure 3 presents current best estimates of the construction schedule required to meet a plant start-up date of 1981.

IX. TRANSPORTATION AND LOGISTICS

Transportation requirements to construct and operate the Niglintgak gas development project will include several methods of travel including aircraft, barges and various modes of overland vehicles possibly including hovercraft.

Primary air traffic from southern Canada will make use of the Inuvik airport. Personnel and air cargo destined for the Niglintgak plant will be transhipped to the Farewell staging area located some 10 miles south of the plant by fixed wing STOL aircraft and from there to the plant by helicopter. There will be no permanent airstrip constructed at Niglintgak.

Barge traffic on the Mackenzie River system will transport such materials as fuel, chemicals, drilling rigs and supplies, construction equipment and smaller construction materials.

Larger construction materials and gas plant modules will be transported to the site via ocean going barge from Vancouver or other west coast ports. Offloading and transportation of modules will be by self-powered transporters.

Site preparation at the plant area, the dock and staging area, and the road between the staging area and the plant will be carried out before arrival of the modules, to provide an all-weather surface to carry the module loads.

X. OPERATIONS

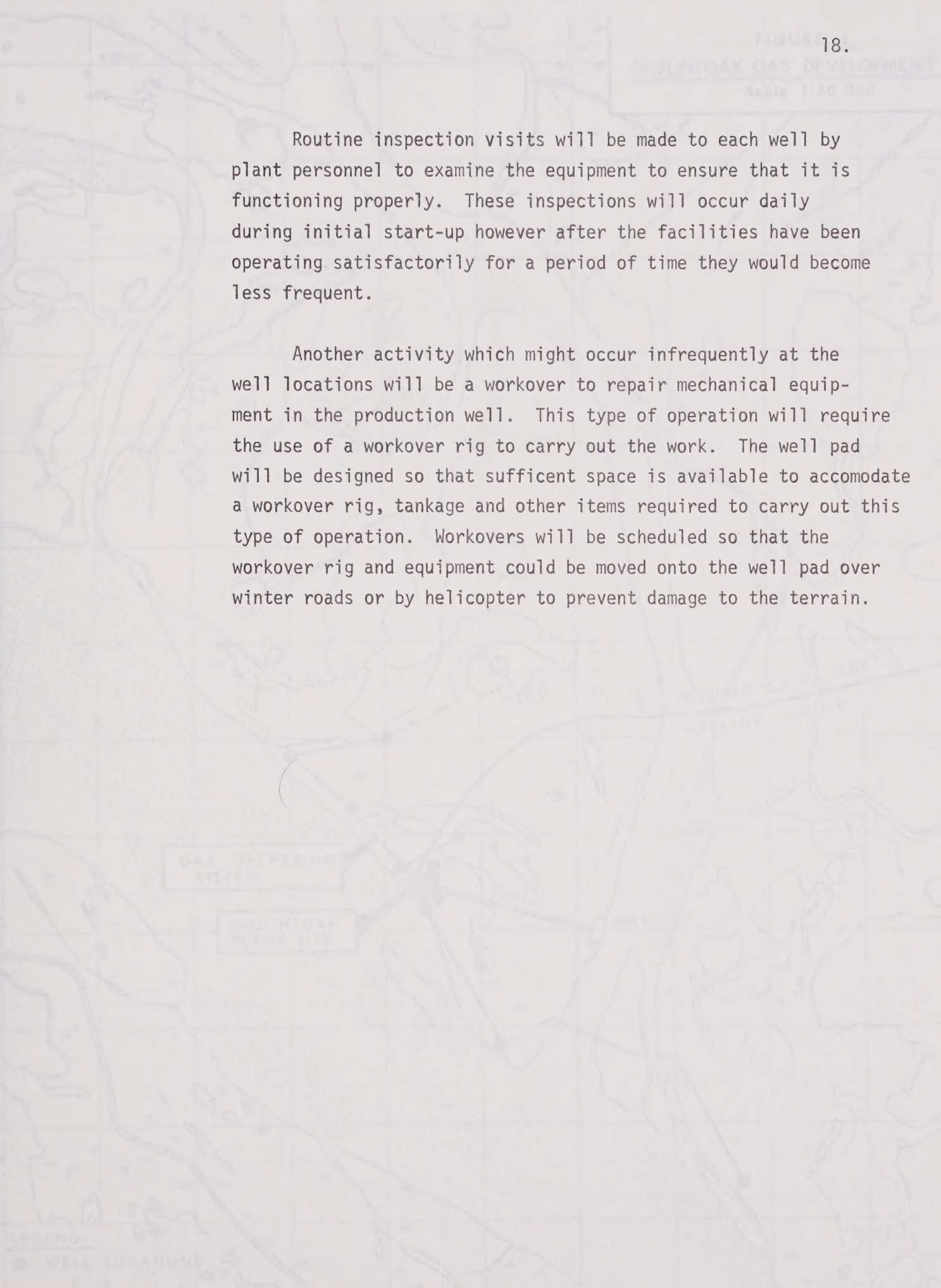
Both the gas plant and the field facilities will be operated from a central control room located at the plant site. The plant and field facilities will be self supporting as far as qualified operations and maintenance personnel are concerned, with a crew of about 15 men on site at all times. A maintenance shop will be provided to service the plant and field equipment. An airstrip is presently available at the nearby Shell Farewell staging area. The operating and maintenance crew will be flown in to this airstrip and from there will be taken to the plant site by helicopter. The crews will rotate on a 2 week in, 2 week out basis. Accomodation facilities will be provided at plant site for the crew. A large proportion of the equipment and supplies for the plant will be brought in by barge to the river dock and barge unloading facility on the Kumak Channel. The dock and all other remote facilities will be operated by staff housed at the Niglintgak plant.

All well facilities will be designed to operate completely unattended and as trouble free as possible. End devices strategically located at the wells and tied into the gas plant will permit remote monitoring of well operations from the gas plant.

The surface safety valve located at each well site will be designed to automatically shut-in if unusual temperature or pressure conditions occur in the well facilities. The valve will also be capable of being remotely shut-in from the gas plant if required.

Routine inspection visits will be made to each well by plant personnel to examine the equipment to ensure that it is functioning properly. These inspections will occur daily during initial start-up however after the facilities have been operating satisfactorily for a period of time they would become less frequent.

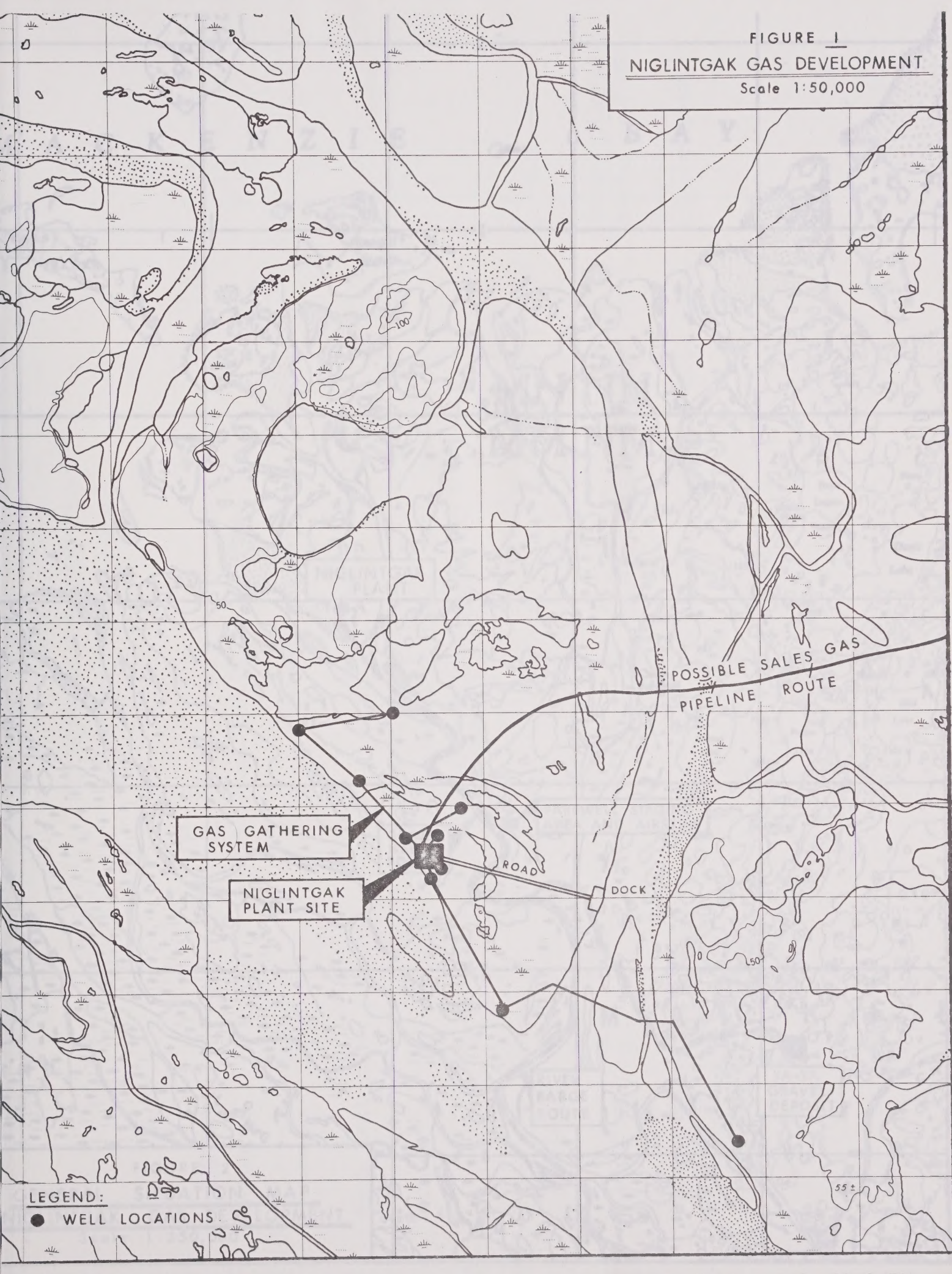
Another activity which might occur infrequently at the well locations will be a workover to repair mechanical equipment in the production well. This type of operation will require the use of a workover rig to carry out the work. The well pad will be designed so that sufficient space is available to accommodate a workover rig, tankage and other items required to carry out this type of operation. Workovers will be scheduled so that the workover rig and equipment could be moved onto the well pad over winter roads or by helicopter to prevent damage to the terrain.



GAS GATHERING
SYSTEM

HIGHLIGHT GAK
PLANT SITE

FIGURE 1
NIGLINTGAK GAS DEVELOPMENT
Scale 1:50,000



LEGEND:
● WELL LOCATIONS



FIGURE 2

GENERAL SITUATION MAP

NIGLINTGAK GAS DEVELOPMENT

Scale 1 250,000

FIGURE 3

NIGLINTGAK GAS DEVELOPMENT PROJECT

DESIGN & CONSTRUCTION SCHEDULE

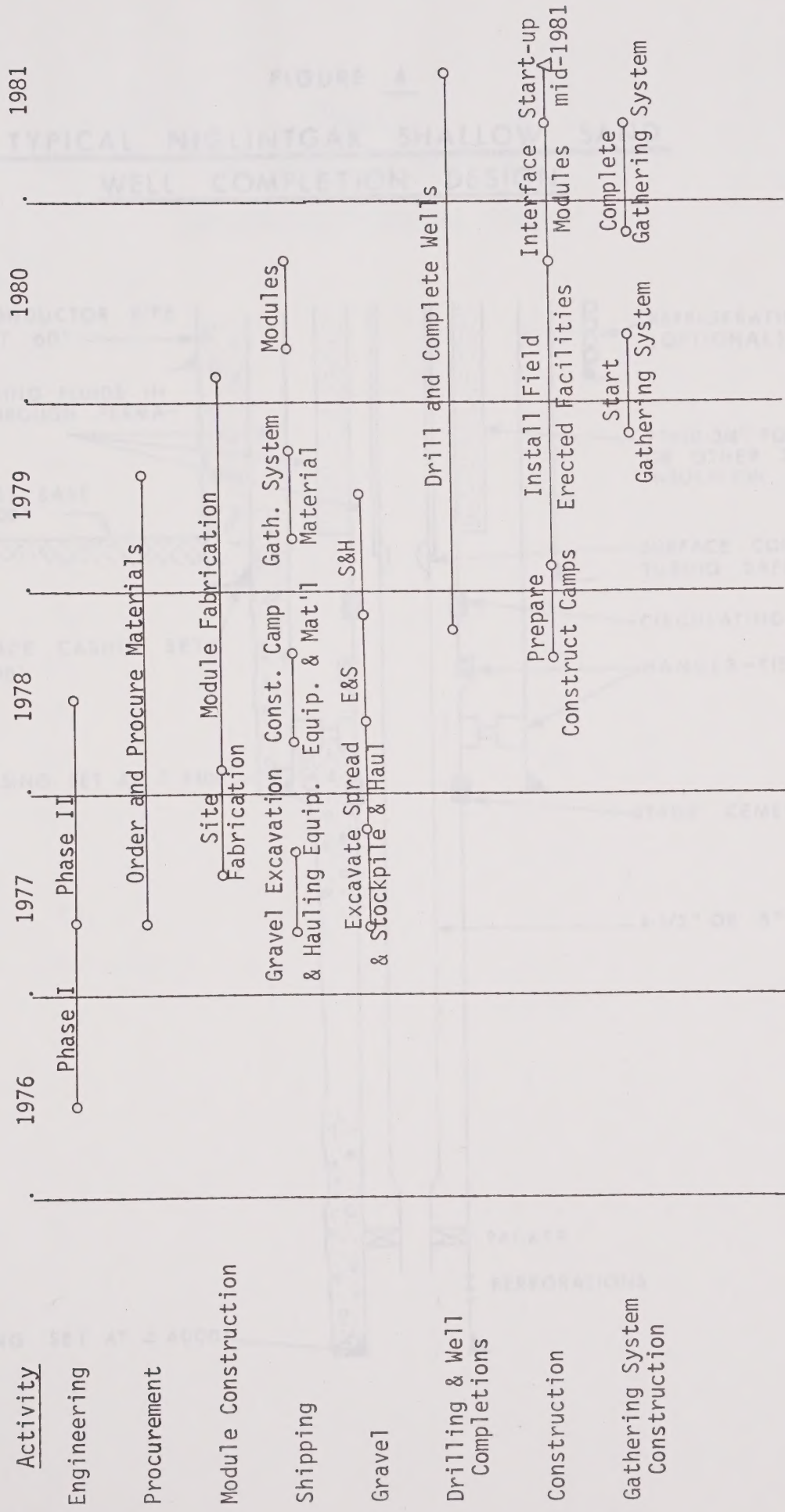


FIGURE 4

TYPICAL NIGLINTGAK SHALLOW SAND
WELL COMPLETION DESIGN

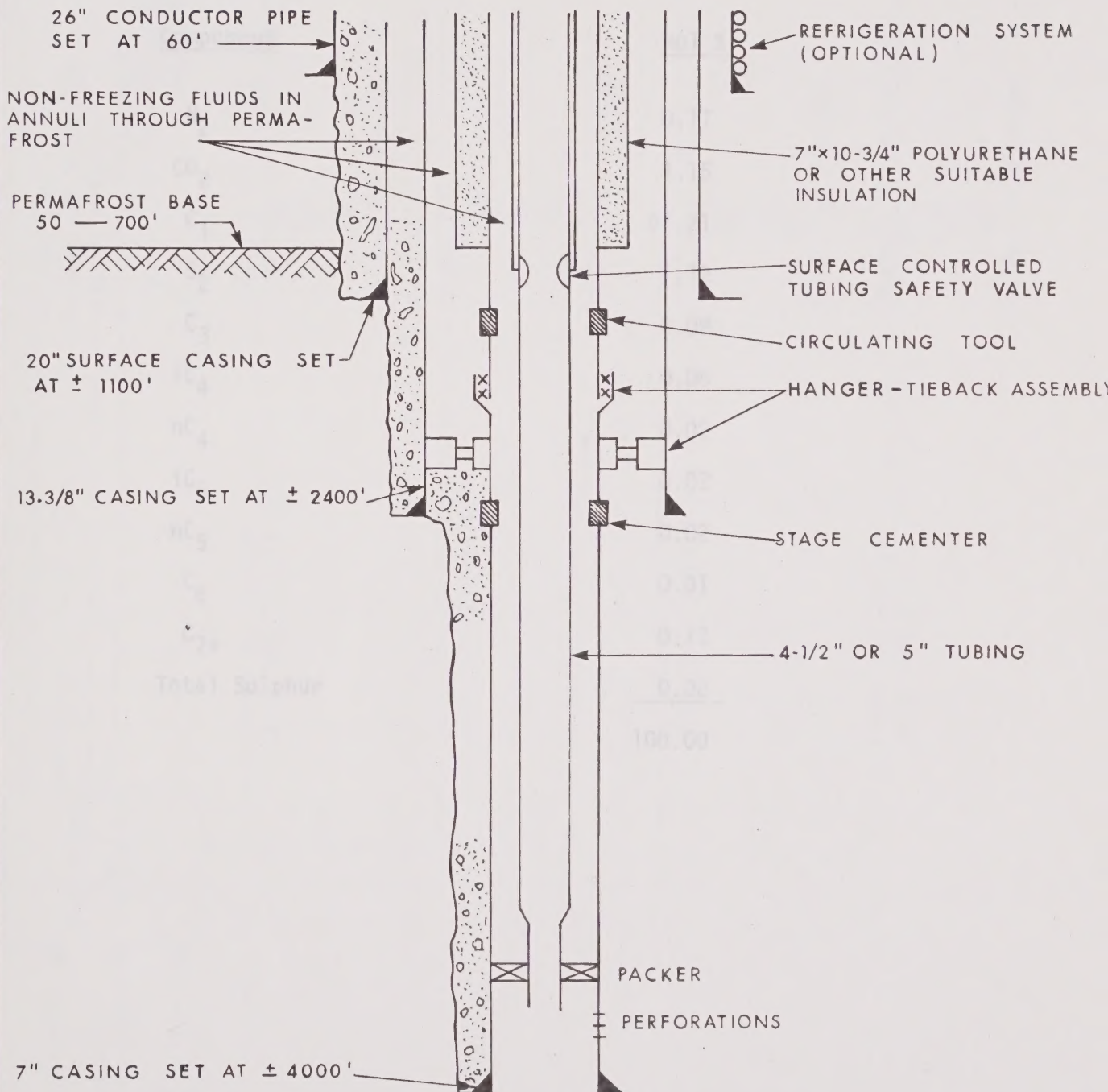


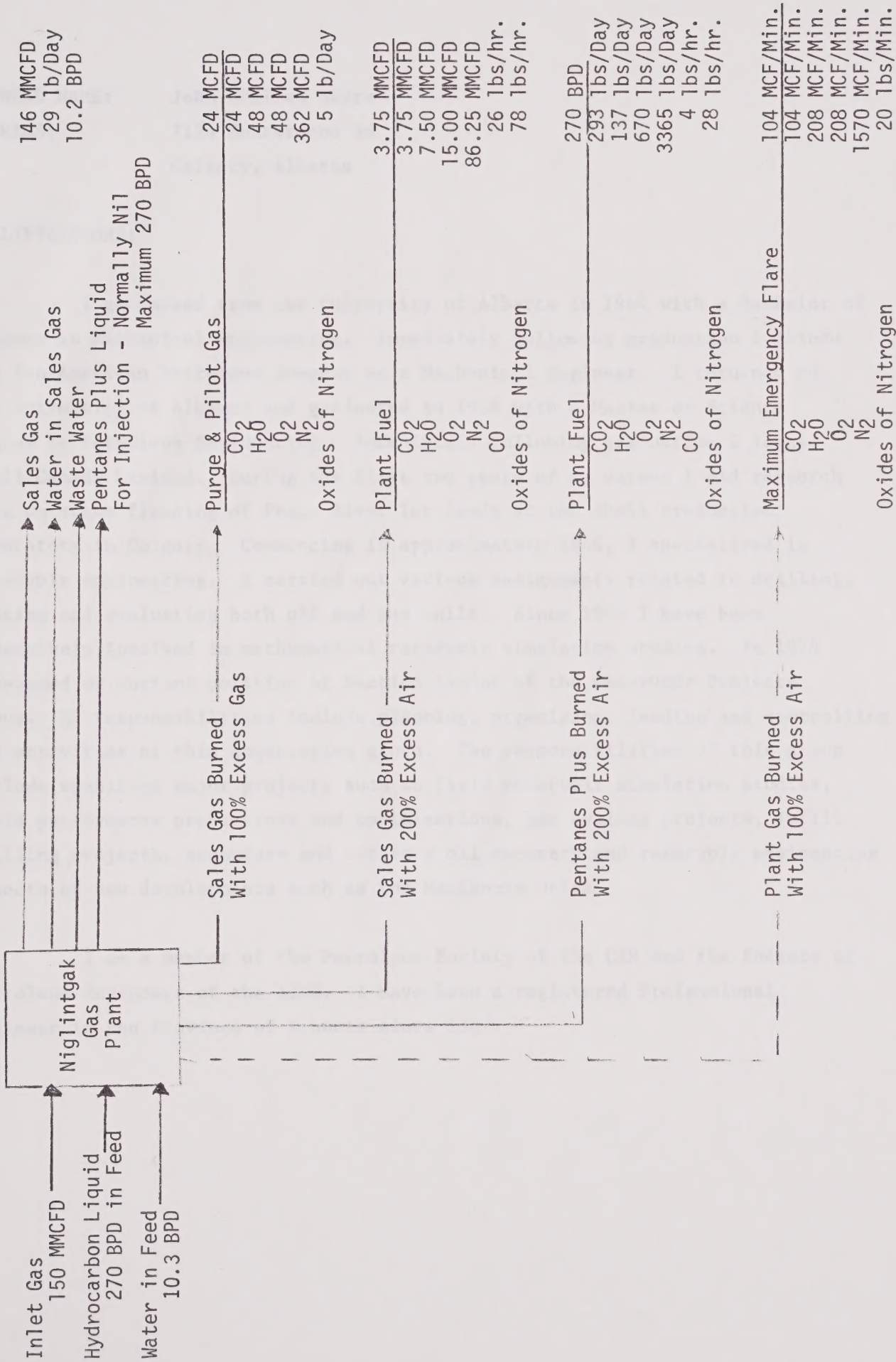
TABLE 1

REPRESENTATIVE ANALYSIS
COMBINED NIGLINTGAK GAS STREAM

<u>Component</u>	<u>Mol %</u>
N ₂	0.17
CO ₂	1.15
C ₁	97.21
C ₂	1.12
C ₃	0.09
iC ₄	0.06
nC ₄	0.02
iC ₅	0.02
nC ₅	0.02
C ₆	0.01
C ₇₊	0.13
Total Sulphur	<u>0.00</u>
	100.00

TABLE 2

MATERIAL BALANCE FOR NIGLINTGAK GAS PLANT



WITNESS NAME: John William Serra
ADDRESS: 7124 Hunterwood Rd
Calgary, Alberta

QUALIFICATIONS:

I graduated from the University of Alberta in 1964 with a Bachelor of Science in Mechanical Engineering. Immediately following graduation I joined the Pan American Petroleum Company as a Mechanical Engineer. I returned to the University of Alberta and graduated in 1966 with a Master of Science degree in Petroleum Engineering. Immediately following graduation I joined Shell Canada Limited. During the first two years of my career I did research work on steam flooding of Peace River Tar Sands at the Shell Production Laboratory in Calgary. Commencing in approximately 1968, I specialized in reservoir engineering. I carried out various assignments related to drilling, testing and evaluating both oil and gas wells. Since 1969 I have been extensively involved in mathematical reservoir simulation studies. In 1974 I assumed my current position of Section Leader of the Reservoir Projects Group. My responsibilities include planning, organizing, leading and controlling the activities of this engineering group. The responsibilities of this group include specified major projects such as field reservoir simulation studies, field performance predictions and optimizations, gas cycling projects, infill drilling projects, secondary and tertiary oil recovery and reservoir engineering aspects of new developments such as the Mackenzie Delta.

I am a member of the Petroleum Society of the CIM and the Society of Petroleum Engineers of the AIME. I have been a registered Professional Engineer in the Province of Alberta since 1967.

WITNESS NAME: Robert Elliott Faulkner
ADDRESS: 124 Lake Lucerne Close S.E.
Calgary, Alberta

QUALIFICATIONS:

I graduated from the University of British Columbia in 1964 with a Bachelor of Applied Science degree in Civil Engineering. I joined Shell Canada Limited in June 1964 as a Mechanical Engineer in the Production Department. After initial assignments in production engineering in Calgary and Edmonton, I spent some 3-1/2 years as an engineer on Shell Canada Limited's West Coast Offshore drilling project working on underwater equipment design and drilling operations. Following the completion of that project I spent approximately 3-1/2 years in offshore drilling and construction operations with Shell Group companies in New Zealand and the United Kingdom. I returned to Shell Canada in late 1972 and became involved in planning for a Mackenzie Delta gas development shortly thereafter. I assumed my current position as Division Projects Superintendent in mid-1974. My responsibilities include planning, organizing and supervising the efforts of a group of engineers and foremen involved in the construction of oil and gas producing facilities in the conventional producing areas in the western provinces of B.C., Alberta and Saskatchewan. Until recently my responsibilities have also included some coordination of Shell Canada Limited's plans to develop the Niglintgak gas reserves in the Mackenzie Delta. My involvement in Delta planning has been primarily in the areas of well completions, well facilities and gas gathering systems.

I have been a registered Professional Engineer in the Province of Alberta since 1966.

